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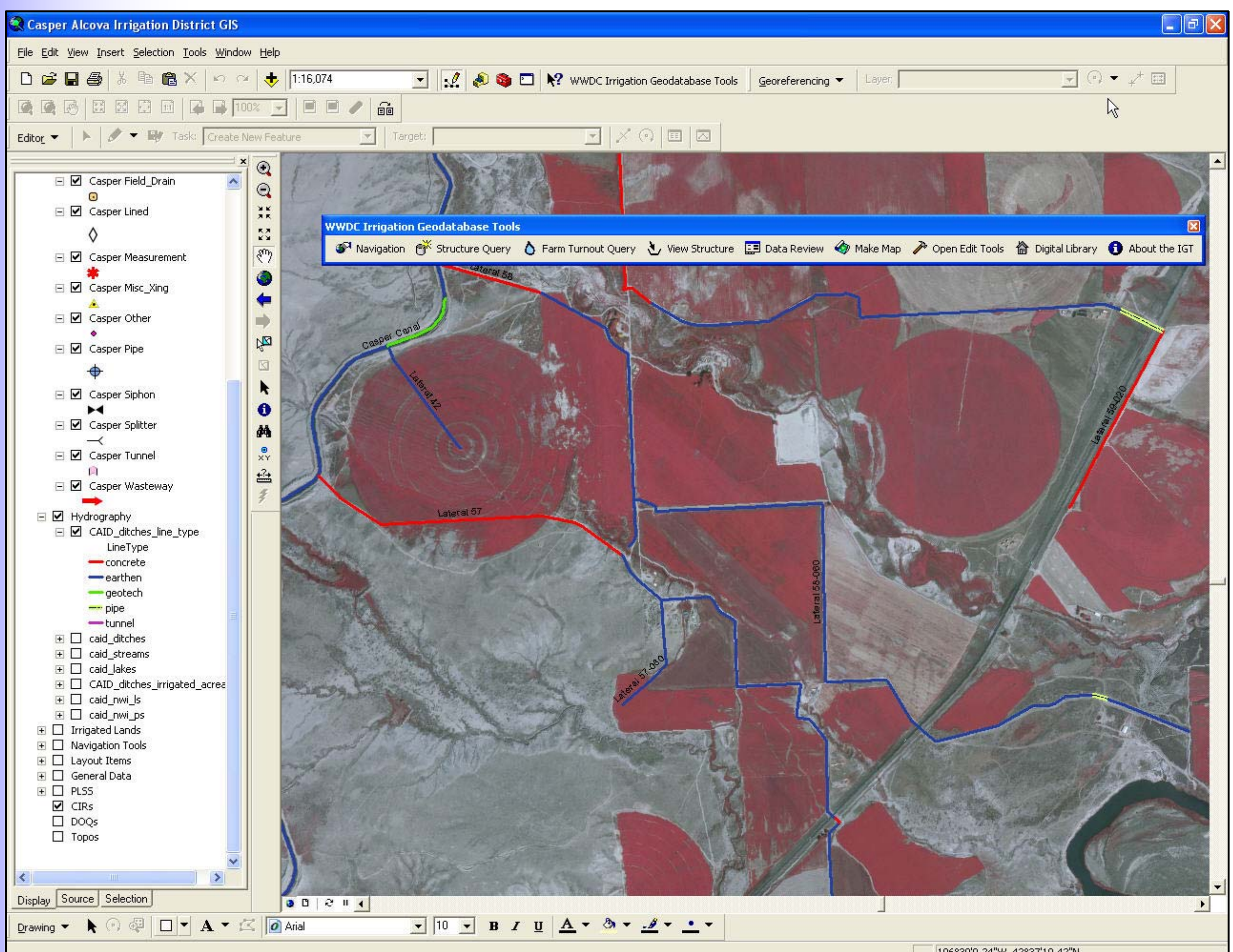
EXECUTIVE SUMMARY
FOR
CASPER ALCOVA IRRIGATION DISTRICT
GIS PROJECT, LEVEL II STUDY

Prepared For:

Wyoming Water Development Commission
6920 Yellowtail Road
Cheyenne, WY 82002



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Civil • Water Resources • Environmental

January 4, 2008

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The original signature and P.E. stamp are presented on the reproducible original document available at the Water Development Office.

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I. INTRODUCTION

On June 15, 2006, Anderson Consulting Engineers, Inc. (ACE) entered into a contract with the Wyoming Water Development Commission (WWDC) to provide professional services for the Casper Alcova Irrigation District (CAID). The purpose of the project was to develop a user-friendly Geographic Information System (GIS) that incorporates a database of information collected during a comprehensive inventory of irrigation infrastructure. The GIS and its database provides the CAID with a dynamic tool to facilitate the planning and development of manpower and equipment resources as well as defining their rehabilitation needs. The work effort included an inventory and assessment of existing structures and facilities, development of conceptual designs for structure replacement and rehabilitation, estimation of the costs associated with implementation of system improvements, and development of the Project GIS.

II. DATA COLLECTION

Initial data collection efforts concentrated on the compilation and review of spatial data already generated and put into use by other local, state and federal agencies. Pertinent spatial data were collected from these agencies and incorporated into the Project GIS. ACE also incorporated information from previously published investigations funded by the WWDC which were specific to the CAID.

III. SEEPAGE INVESTIGATION

A seepage investigation was conducted which consisted of the evaluation of existing data, analysis of color infrared photography, and the results of a water budget/gaging analysis of selected laterals. Results of the study indicated the following:

- Lateral water budgets indicate that earthen laterals typically lose approximately 5% to 15% of diverted water to seepage. Most of these losses translate to losses of less than 1 cfs at the diversions measured during the study.
- Lateral 256 appears to consistently display seepage losses. Estimates ranged as high as 13.6% for the reach between the measurement structure and the existing lined section. The condition of structures within this reach also indicates that underlying materials may be conducive to seepage as evidenced by significant piping and undermining of structures in many locations.
- The CAID has recently initiated automation of the Lateral 256 headgate. When completed, measurement of diversions will be possible *at the headgate*. This capability will enable the CAID to easily compare flows at the headgate and at the measurement structure located approximately 3.3 miles downstream. CAID representatives have indicated that they believe this reach suffers significant seepage.
- Canal underdrain culverts typically leak; the magnitude of the leakage varies greatly at each structure. The leakage has not been quantified, however, field observations of the culverts and the channels crossing the canal verify the leakage is occurring. Canal lining projects may be feasible at selected underdrains. The linings would serve not only to reduce seepage from a conservation standpoint, but also to help preserve deteriorating underdrains and extend their life expectancy. Lining projects at

underdrain culverts would typically extend approximately 150 feet upstream and downstream of a culvert (300 feet total).

IV. GIS DEVELOPMENT

A project GIS was developed which incorporated the results of the field inventory and assessment effort. The following types of structures were located and evaluated:

Check Structures	Culverts	Drop Structures
Farm Turnouts	Diversions	Measurement Devices
Lined Reaches	Siphons	Wasteways
Bridges	Pipeline Crossings	Field Drain Outlets
Channel Features	Tunnels	

Irrigation Geodatabase Tool

An important objective of the project was to create a GIS, which the layman could use and obtain useful information and mapping without specialized training. ACE developed Version 1 of the Irrigation Geodatabase Tool (IGT), which takes the user "by the hand" and guides them through key functions of the GIS. It consists of a suite of individual tools, developed using Visual Basic, that enable even the novice user to utilize the powerful functionality of the GIS, to review existing data, and to modify and edit data. Utilization of the Project GIS and the IGT requires installation of ARCView version 9.2 and Microsoft Access software.

IGT Navigation Tools : The Navigation tools enable the GIS user to navigate spatially throughout the areal extent of the GIS. Using pull down menus, the user can select any of three means of modifying the visible extent of the GIS: Township/Range/Section, canal segment, or map book page.

IGT Query Tool: The Query Tool allows the user to query the data contained within geodatabase to extract information such as structure condition, functionality, and rehabilitation needs. The user can generate a list of structures meeting the search criteria, which can be based upon canal system, type of structure, and overall condition.

IGT Data Review Table: The Data Review Table (DRT) can be considered the "workhorse" of the customized tools. A primary function of the DRT is to present the feature attributes and associated data in a clear and easy to read format. The DRT is divided into five distinct tables: Description, GPS Data, Maintenance Memos, Photographs, and Summary. In addition, the DRT facilitates data editing within the form and report generation.

IGT Map Tool: This tool allows the user to generate formatted maps of any GIS view. By clicking on Make Map, the GIS automatically switches to ArcView's layout mode and initiates the generation of a map using user-selected criteria.

IGT New Feature: As structures are replaced or new structures added to any of the irrigation systems, the user can add them to the geodatabase using this feature.

In summary, the IGT consists of a suite of GIS tools developed specifically for the irrigation district manager and its individual water users.

V. STRUCTURE INVENTORY AND EVALUATION

The CAID distribution system was inventoried during the non-irrigation season beginning in the Fall of 2006 and ending in the Spring of 2007. Over 1,500 structures and features were inventoried and evaluated during this phase of the project. Table 1 summarizes the numbers of structures and their condition inventoried within the CAID system. Figure 1 summarizes the relative distribution of different types of conveyance structures in the CAID. This figure omits the individual farm turnouts, bridges, channel features (erosion, sedimentation, etc.), and miscellaneous crossings (utilities, water lines, etc.).

For every conveyance structure inventoried, field crews assigned an overall condition ranging from “failing” to “good”. This information is summarized in Figure 2. As displayed in this figure, the majority of structures were classified as being in ‘good’ or ‘fair’ condition. Only 7.1 percent of the conveyance structures inventories were classified as being in ‘poor’ condition and 1.6 percent as ‘failing’. These percentages, while relatively low in magnitude, represent a total of approximately 94 structures (77 poor and 17 failing).

As indicated in Figure 2, nearly 8.7 percent of the structures inventoried in the CAID system were rated as either “poor” or “failing” condition. Replacement is recommended for all failing structures. Poor structures, on the other hand, were often earmarked for partial rehabilitation at significantly lower costs.

Rehabilitation Prioritization

In an effort to prioritize replacement of individual structures with the CAID, a database was generated. The database incorporated data for every structure evaluated during the inventory phase of the project which was classified as either “poor” or “failing”. Data within the database include overall condition, number of irrigated acres dependent upon the structure, and type of structure.

A Structure Assessment Index was computed and provided a means of ranking various types of structures within an irrigation district. The method of computing the Structure Assessment Index is described below:

- The Asset Priority Index (API) represents the service area (irrigated acres) served by each structure. Structures with higher API are considered more vital to the CAID than those with low API. The total service area for the CAID is 22,971 acres.
- The Facilities Condition Index (FCI) represents the approximate ratio of structure rehabilitation cost to replacement. For example, a failing structure would require replacement, or 100 percent of its cost to replace.

  The Structure Weight Index represents the relative importance to the CAID of the structure based on its type. For example, a measurement device is not critical to the CAID’s deliveries; a siphon is. Consequently, the siphon would be assigned a higher weight than a measurement device.

Table 1. Tabulation of Results of the CAID System Inventory.

Structure Type	Condition					
	Good	**Fair**	**Poor**	**Failing**	**Condition Not Assessed**	**Total**
Conveyance Structures						
Canal Headgates	67	20	0	0	--	**87**
Check Structures	28	82	10	4	--	**124**
Culverts	125	112	30	1	--	**268**
Drop Structures	150	56	14	4	--	**224**
Lined Reaches	35	39	0	2	--	**76**
Measurement Devices	100	35	8	6	--	**149**
Pipe Inlets/Outlets	49	3	1	0	--	**53**
Siphon Inlets/Outlets	45	16	7	0	--	**68**
Splitters	11	1	1	0	--	**13**
Tunnel Inlets/Outlets	3	6	3	0	--	**12**
Wasteways	6	3	3	0	--	**12**
Subtotal	**619**	**373**	**77**	**17**	**0**	**1086**
Additional Structures						
Bridges	8	7	6	0	--	**21**
Channel Feature	Condition Not Assessed				60	**60**
Farm Turnouts	Condition Not Assessed				369	**369**
Miscellaneous Crossings	Condition Not Assessed				29	**29**
Subtotal	**8**	**7**	**6**	**0**		**479**
Grand Total	**627**	**380**	**83**	**17**	**458**	**1565**

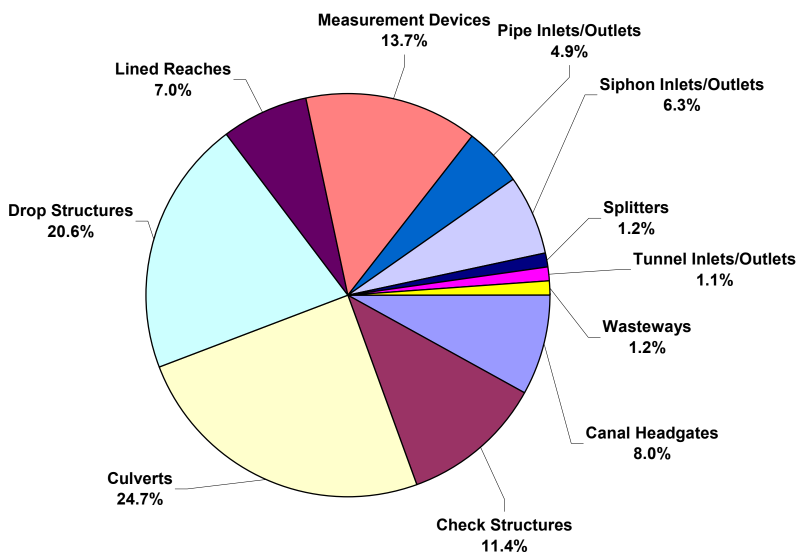

Figure 1. Relative Distribution of Conveyance Structure Types within the CAID.

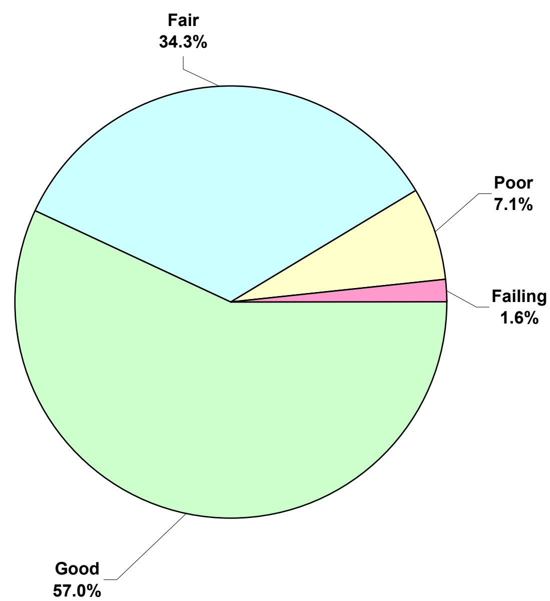

Figure 2. Relative Distribution of Overall Condition: CAID Canal/Lateral System.

- The Structure Assessment Index is computed as the product of the three indices presented above divided by 1,000. By ranking the inventoried structures based on their Rehabilitation Indices, the CAID can get a realistic "roadmap" of rehabilitation projects and the order which they should be completed.

For the purposes of this project, all conveyance structures which were classified as either 'poor' or 'failing' condition were assigned a Structure Assessment Index within the database. The database was then sorted based upon the Index and presented as a prioritized list of rehabilitation projects which the CAID can use as a 'road map' for future rehabilitation scheduling and project funding planning. This list is intended to serve as a general plan of improvements based upon the relative value of a structure to CAID operations. The CAID may follow a different order based upon factors such as availability of funds.

In addition to the prioritized rehabilitation plan, the following general observations and recommendations are provided.

- The Bureau of Reclamation constructed an upslope diversion (catch) ditch at the time the system was built. The purpose of the ditch is to capture surface runoff from upslope and convey it to underdrain culverts or other designed locations thereby preventing storm surcharges, canal bank erosion, etc. Inventory and evaluation of this feature was beyond the scope of this project. However, during the completion of this project, ACE received input from CAID and several landowners regarding its condition. Spot observations of the catch ditch confirmed that inspection and remediation of the ditch are warranted. For example, at Mile 19.31, bridge replacement has disturbed the diversion ditch configuration. The reconstructed road blocks the ditch causing runoff to erode the canal bank.
- Fences spanning the canal were observed in numerous locations. These fences tend to capture debris, impede canal flow conditions, and can cause or exacerbate bank erosion. Consideration should be given to removal of these fences prior to the irrigation season.
- Blow-off valves of every siphon were either inoperable or absent. All siphon blow-off valves should be inspected and replaced.
- Seepage studies indicate that at the time of the investigation, most laterals did not exhibit losses of a sufficient magnitude to warrant conversion to pipelines. Several laterals indicated losses in excess of ten percent. However, given the ambient flow conditions, the magnitude of loss was typically less than 1 cfs. CAID should continue to evaluate seepage losses in an effort to quantify losses at higher discharges. With these issues in mind, the laterals which appear most likely candidates for conversion to pipeline include the following:
    - Lateral 160,
    - Lateral 174,
    - Lateral 232, and
    - Lateral 239.
- Lateral 256 indicated losses in two reaches which may be of sufficient magnitude to warrant lining projects. Conversion of these reaches of Lateral 256 to a pipeline is not cost effective due to the magnitude of the diversion and the pipe required to convey the irrigation deliveries.

VI. AUTOMATION OF EXISTING FACILITIES

Automation of the existing facilities represents a significant opportunity to conserve water and improve management and delivery of water to all users within the CAID. Results of the investigation identified nineteen (19) sites for automation (see Table 2). Radio telemetry is recommended for the communications network. The recommendations also include installation of a base station within the CAID office. Additional communications and processing equipment and software are included to enable two-way communications, to command the control of slide gates remotely, and to evaluate the flows within the irrigation delivery system relative to the operational objectives of the CAID. The CAID has initiated the automation of their system with the establishment of the CAID Base Station and automation of the Poison Spider Check structure and the Lateral 256 headgate / 48.91 check structure.

Table 2. Potential Automation Sites

Location	Requirements
Casper Canal V-Notch Weir	Monitoring Only
Casper Canal Lateral 60 Check	Monitoring and Gate Automation
Lateral 102 Check	Monitoring and Gate Automation
Casper Canal Mile 48.91 Check/ Lateral 256 Headgate (1)	Monitoring and Gate Automation
Lateral 128 Headgate	Monitoring and Gate Automation
Lateral 210 Headgate	Monitoring and Gate Automation
Lateral 218 Headgate	Monitoring and Gate Automation
Lateral 328 Headgate	Monitoring and Gate Automation
Casper Canal Mile 61.52 Spill	Monitoring Only
Lateral 256 Spill	Monitoring Only
Lateral 128 Spill	Monitoring Only
Casper Canal Poison Spider Check (1)	Monitoring and Gate Automation
Tunnel No. 6 Inlet Check	Monitoring and Gate Automation
Lateral 256 60" Gate and 15-ft weir	Monitoring and Gate Automation
Lateral 218 Spill	Monitoring Only
Lateral 147 Spill	Monitoring Only
Lateral 210 Spill	Monitoring Only
Lateral 147 Headgate	Monitoring and Gate Automation
District Office – Mills (1)	Base Station / Base Station Software

(1) Initial automation site (2007)

VII. CONCEPTUAL DESIGNS AND COST ESTIMATES

The information developed during the design process was utilized to generate cost estimates for implementation of the individual improvements. The conceptual design of the structures identified for rehabilitation or replacement relied on information obtained during the field inventory and assessment or references illustrating typical design drawings for irrigation structures.

A final cost estimate and repayment plan, presented in Table 3, was generated for the project improvements involving replacement of structures. As indicated in Table 3, the final cost estimate and repayment plan includes 10% for engineering services during construction and 15% for construction contingencies. With respect to the repayment plan, the total project cost for each improvement was utilized to determine the annual loan payment requirements (assuming WWDC funding is provided in the form of a 67 percent grant and 33 percent loan).

Recommendations for rehabilitation of those structures in 'poor' or 'failing' condition which were not recommended for replacement were also developed, along with costs for rehabilitation were also estimated.

VIII. CONCLUSIONS AND RECOMMENDATIONS

This document presents the results of a study intended to generate a digital Geographic Information System (GIS) for the CAID. The GIS is intended to serve as a tool for the CAID to use to facilitate management of data, evaluate its system condition and integrity, and to be a means of providing maps and valuable information to the CAID and the public.

This work included an inventory and assessment of existing structures and facilities, evaluation of system losses, development of conceptual design and costs associated with irrigation system improvements, and development of a prioritized implementation plan. Based on the information presented in the previous chapters, the following conclusions and recommendations are provided.

- A Geographic Information System (GIS) was developed for the CAID following completion of the field inventory of canal and lateral system infrastructure. The project GIS included a wide variety of information collected from existing sources and developed during the course of this project. Data collected from existing sources included coverages such as public land survey (PLSS), roads, parcel mapping, and hydrography, among others. It also included background imagery such as color infrared photography and USGS topographic mapping. Results of the field inventory and assessment of approximately 1,565 individual structures associated with the CAID was incorporated in the project geodatabase.
- An Irrigation Geodatabase Tool (IGT) developed by ACE during previous investigations funded by the WWDC was incorporated into the project GIS. The IGT was developed to enable the district manager to navigate the GIS, to utilize the databases, and to generate maps. The IGT consists of a suite of tools developed using Visual Basic and packaged into a user-friendly graphic user's interface (GUI). The IGT allows the user to query the extensive geodatabase to extract information such as structure condition, functionality, and rehabilitation needs. The IGT facilitates data editing in an easy to read data form, bypassing cumbersome editing routines otherwise required by the GIS software. Navigation is facilitated via any of several options: Public Land Survey System, Map Index, Canal Segment, or water user's farm turnouts. Maps can then be formatted and printed within a menu driven interface.
- A Digital Library was developed which facilitates the incorporation of any digital information into an accessible and concise format. The CAID can use the Digital Library

Table 3 Construction and Total Project Cost Estimates - Structure Replacement.

Priority/Item Number	Structure Type	Canal/Lateral Station (mile)	Cost of Project Components	Total Construction Costs	Total Project Cost	Annual Payment[(1)]	Assessment[(2)] (Cost/Acre)
1	Culvert	17.15	$107,887	$136,477	$153,301	$3,722	$0.15
22	Culvert	44.87	$229,701	$290,572	$315,100	$7,651	$0.32
23	Culvert	47.51	$109,037	$137,932	$154,829	$3,760	$0.16
24	Culvert	48.26	$123,315	$155,993	$173,792	$4,220	$0.18
26	Drop	3.11	$111,889	$141,540	$158,617	$3,852	$0.16
27	Drop	3.35	$111,889	$141,540	$158,617	$3,852	$0.16
37	Lined	3.23	$145,200	$183,678	$202,862	$4,926	$0.20
38	Check	1.38	$30,924	$39,118	$54,118	$1,314	$0.05
39	Check	2.33	$15,755	$19,930	$26,430	$642	$0.03
40	Check	2.77	$26,174	$33,110	$48,110	$1,168	$0.05
41	Drop	1.54	$45,080	$57,026	$72,026	$1,749	$0.07
42	Drop	0.25	$30,648	$38,769	$53,769	$1,306	$0.05
43	Drop	1.04	$30,648	$38,769	$53,769	$1,306	$0.05
44	Check	3.75	$26,174	$33,110	$48,110	$1,168	$0.05
45	Culvert	3.71	$30,579	$38,682	$53,682	$1,304	$0.05
47	Check	0.89	$12,305	$15,566	$22,066	$536	$0.02
48	Culvert	2.36	$16,284	$20,599	$27,099	$658	$0.03
49	Culvert	2.49	$16,284	$20,599	$27,099	$658	$0.03
50	Measurement	0.21	$10,753	$13,602	$20,102	$488	$0.02
52	Culvert	1.02	$16,284	$20,599	$27,099	$658	$0.03
56	Culvert	2.50	$15,548	$19,668	$26,168	$635	$0.03
57	Check	4.76	$22,724	$28,746	$35,246	$856	$0.04
59	Measurement	0.26	$9,419	$11,914	$18,414	$447	$0.02
60	Drop	0.52	$30,648	$38,769	$53,769	$1,306	$0.05

Table 3 Construction and Total Project Cost Estimates - Structure Replacement (Continued).

Priority/Item Number	Structure Type	Canal/Lateral Station (mile)	Cost of Project Components	Total Construction Costs	Total Project Cost	Annual Payment[(1)]	Assessment[(2)] (Cost/Acre)
61	Drop	0.67	$30,648	$38,769	$53,769	$1,306	$0.05
62	Drop	1.07	$30,648	$38,769	$53,769	$1,306	$0.05
63	Drop	1.42	$31,234	$39,511	$54,511	$1,324	$0.05
67	Check	0.17	$16,054	$20,308	$26,808	$651	$0.03
68	Measurement	0.03	$4,439	$5,615	$12,115	$294	$0.01
69	Measurement	0.04	$27,916	$35,314	$50,314	$1,222	$0.05
71	Measurement	0.36	$9,873	$12,489	$18,989	$461	$0.02
72	Culvert	2.73	$17,503	$22,141	$28,641	$695	$0.03
74	Check	1.75	$15,755	$19,930	$26,430	$642	$0.03
75	Measurement	0.08	$2,420	$3,061	$9,561	$232	$0.01
76	Wasteway	3.67	ontained within Splitter Box CSP-SP-0		$0	$0	$0.00
77	Measurement	6.23	$9,873	$12,489	$18,989	$461	$0.02
78	Lined	0.08	$6,738	$8,523	$15,023	$365	$0.02
79	Splitter	3.67	$30,015	$37,969	$52,969	$1,286	$0.05
82	Measurement	0.31	$9,873	$12,489	$18,989	$461	$0.02
83	Measurement	1.89	$10,753	$13,602	$20,102	$488	$0.02
84	Drop	0.40	$55,623	$70,363	$85,363	$2,073	$0.09
86	Measurement	5.58	$12,708	$16,075	$22,575	$548	$0.02
88	Culvert	2.40	$12,616	$15,959	$22,459	$545	$0.02
90	Measurement	0.07	$6,843	$8,656	$15,156	$368	$0.02
92	Measurement	2.47	$9,873	$12,489	$18,989	$461	$0.02
94	Check	0.15	$15,755	$19,930	$26,430	$642	$0.03
					$2,636,149	**$64,011**	**$2.66**

Casper Canal Liner Projects at Selected Underdrains: (10 underdrains)

Each	Lined	Varies	$90,000	$113,850	$129,543	$3,146	$0.13
					$1,295,425	**$31,455**	**$1.31**

to collate documents, reports, photos, design drawings, etc. in a paperless library for future use and archival.

- A map atlas was generated which included mapping of irrigated acreage and irrigation infrastructure projected on both USGS topographic mapping and color infrared photography.
- Over 1,500 structures (including farm headgates and measurement devices) were inventoried and evaluated during the completion of the project. The results of the structure inventory provide a snapshot of the overall condition of the irrigation structures within the CAID in 2006 and 2007. Of these, 1,086 (not including measurement structures) were classified as conveyance elements. Approximately 10% were found to be poor or failing condition (77 were in poor condition and 17 were failing).
- Structures deemed to be in 'poor' or 'failing' condition were included in a prioritized rehabilitation plan. The prioritization process was completed using an algorithm which includes factors such as the type of structure to be rehabilitated, the number of irrigated acres dependent upon its functionality, and its relative condition. The plan is provided as a starting point for the CAID to use for rehabilitation planning.
- The seepage investigation indicated that earthen laterals typically lose approximately 5% to 15% of diverted water to seepage. Given the magnitude of losses in terms of cubic feet per second or acre-feet, most laterals do not appear to be candidates for pipeline conversion strictly from a water conservation standpoint. The exception to this may be Lateral 256. Substantial conservation savings could be achieved with lining of selected reaches.
- Canal underdrain culverts typically leak; the magnitude of the leakage varies greatly among culverts. The leakage has not been quantified, however, field observations of the culverts and the channels crossing the canal verify the leakage is occurring. Canal lining projects may be feasible at selected underdrains. The linings would serve not only to reduce seepage from a conservation standpoint, but also to help preserve deteriorating underdrains and extend their life expectancy. Lining projects at underdrain culverts would typically extend approximately 150 feet upstream and downstream of a culvert (300 feet total). Ten underdrain culverts were identified which would benefit from lining projects from both a water conservation standpoint and extension of their longevity.
- Automation of the existing facilities represents a significant opportunity to conserve water and improvement management and delivery of water to all users within the CAID. Results of the investigation identified 19 sites for automation, including establishment of a base station at the CAID offices in Mills. Radio telemetry was recommended for the communications network. CAID has initiated the automation program by establishing the base station and automation of the 48.91 check/Lateral 256 headgate and the Poison Spider Check structure.
- Conceptual designs and cost estimates were prepared for each component of the rehabilitation plans. For those items selected for Level III design and construction, the CAID should investigate funding through the Wyoming Water Development Commission (WWDC) Grant/Loan program (67% grant/33% loan grant).

Anderson Consulting Engineers, Inc.

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